FEATURE — The Herald — SECTION
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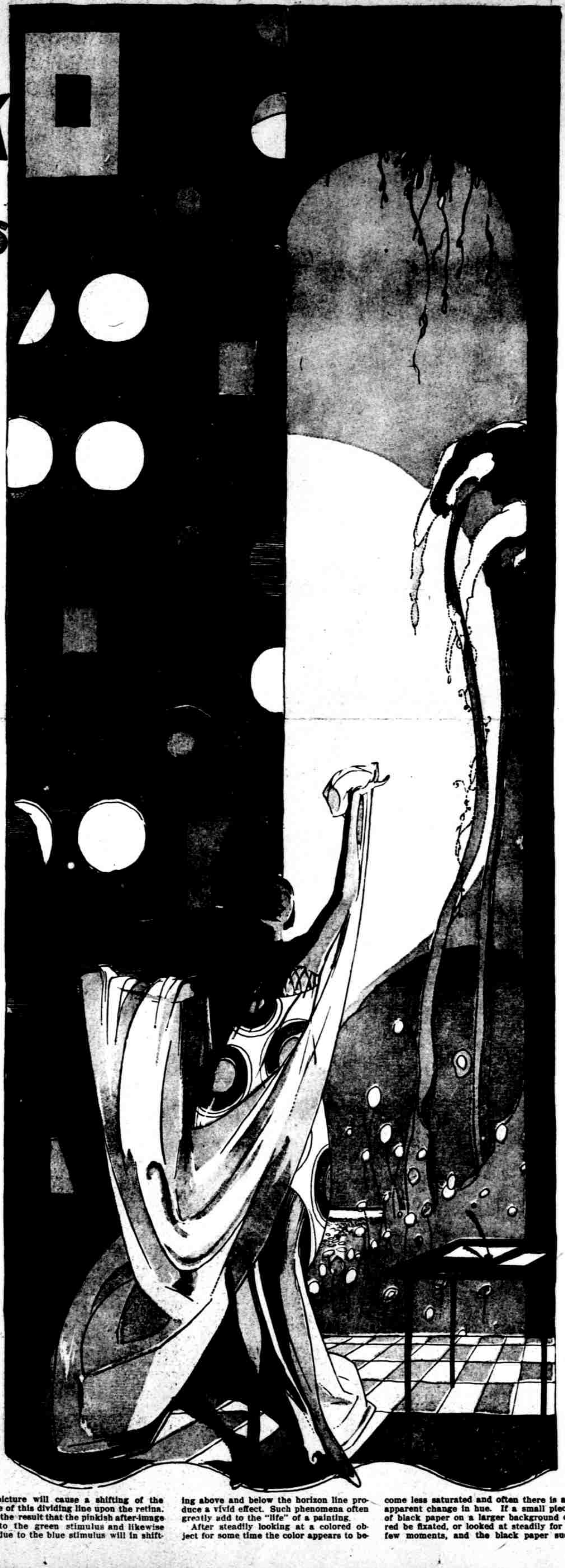
WHEN RED LOOKS BLACK AND WHY CHANGEABLE SILKS CHANGE

When is red light not seen as red light?
Why do painters use orange red to show sunlight?
When does red appear black?
When will a match of colors not remain a match?
Why is changeable silk?
Why do you see green after looking at red?
Why do you see an electric lamp filament after looking at it and closing the eyes?
Why does a pale blue skyline against a green landscape become pink?
When does the same color appear of different hues?
What color makes red appear redder and green greener?
What makes the same gray appear darker or lighter?



STARTLING as these questions are they are all sensible ones and have sensible, startling and for the most part simple answers. The answers are given in an interesting new volume on "Color and Its Applications" by M. Luckiesch, a physicist at the research laboratories maintained by the National Lamp Works at Nela Park. In this new book the author has collected the individual researches of others and combined with them many well-known more or less isolated facts and much new and original data. A pleasing feature regarding this book is that although it is in every sense a scientific treatise of color, [illegible] relations between [illegible] science and [illegible] pointed out. [illegible] article is [illegible] scientific facts treated in this [illegible]

A color in one respect is very much like a human being in that its environment is greatly responsible for its appearance. There are at least nine things that affect the appearance of a given color. They are:

The intensity of a color.
Its spectral character.
The distribution of the light illuminating it.
The adaptation of the eye for light and color.
The duration and the character of the effect on the eye of a color that preceded the one under observation.
The surroundings.
The size and position of the retinal image.
The surface character of the colored medium.

The size of a colored image and its position and duration in the part of the eye which receives it affect its appearance because the eye is not equally sensitive to it in all its parts. An observer in a room with neutral tint surroundings illuminated with pure red light is not conscious of a saturated red color. In the same way if a white paper is placed on a black velvet ground and is illuminated by a moderately intense red light it will appear quite unsaturated owing to the lack of anything with which to contrast it in color. The loss of saturation seems to progress as the observer keeps on looking at the light.

Another interesting experiment in viewing colors which is connected with the rate of growth of color sensations is found in viewing a red piece of paper on a blue-green ground held at arm's length under a moderate illumination. If the paper is moved back and forth with the eye kept steadily fixed the red patch will appear to shake like jelly and will appear not to be in the same plane as the blue-green paper.

Colors ordinarily encountered appear to shift in hue under low illumination. A green pigment, for instance, appears to assume a more bluish hue as the illumination is greatly decreased.

Colors also appear more saturated at low than at high intensities of illumination. In fact intense illumination causes colors to appear very much less saturated. A deep red object illuminated by sunlight directly is painted orange-red by the artist. The employment of this illusion is successful in conveying to the observer the idea of intense illumination. Similarly colors appear more saturated when exposed only for a very short interval of time.

The quality of light affects the appearance of colored objects very much. Except in very special cases a red fabric, for example, appears red because it has the ability to reflect chiefly red rays. Such a fabric will appear black when viewed under a light which contains no red rays, such as a blue or green light.

It is a fundamental principle that except in special cases a colored fabric cannot appear the same under two different illuminants. Therefore two colors that appear alike under one illuminant will not match when viewed under another illuminant unless the colors in each case show the same spectral character by analysis. In other words because the eye is not capable of analyzing a color spectrally it is possible to produce the colors which appear the same but whose spectral compositions differ. Such a match will not remain a match generally under another illuminant differing in spectral character.

In this connection it is difficult to distinguish a blue fabric as blue under ordinary artificial light owing to the scarcity of blue rays in most of the artificial illuminants. Of course a pigment which was absolutely true, that is monochromatic in color, would not be changed in hue under various illuminants but would be altered in brightness. However, no monochromatic colors are found in practice but if pigments that were practically monochromatic existed very generally a greater intensity of illumination would very often be required than at present because such colors would reflect very little light.

A striking instance of the effect of the distribution of light is found in the case of the so-called changeable silks. Such fabrics have a nap and when the fibers end in the direction toward the light the latter penetrates the fabric and is deeply colored by multiple selective reflections. The light that comes from other directions is more or less specularly reflected, as if from a mirror, thus undergoing less change by selective absorption with the result that various portions of the surface appear differently.

The phenomenon of after-images is particularly interesting. After the eye has looked at a color it takes some time for the sensation to cease. If the filament of an incandescent lamp be viewed for an instant and then the eye be closed its image will persist in the eye for some time. This has been called a positive after-image. Soon depending upon the intensity of the stimulus the image will reach a stage of decay when it will appear darker than the surroundings.

If the closed eyelid is illuminated the visual field will appear brighter than in the case where the eyelid is shielded from the light by the hand being placed gently against it. In the former case the after-image will remain positive a shorter time than in the case of the darker surroundings. The same will be found when viewing the after-image against various white or gray backgrounds with the eyelid open.

Positive after-images obtained by looking steadily for a period at a white paper illuminated by sunlight can be seen for a brief period but they rapidly decay to a brightness lower than that of ordinary surroundings. In their decay they pass through a series of hues, namely blue, green, indigo, violet pink, dark orange and so on which are more or less definite.

After-images are also produced by looking steadily at colored objects.

After-images play quite an important part in vision, especially in viewing paintings and many other colored objects. For instance if a pale blue sky line be viewed in juxtaposition with a green landscape the natural shifting of the eye, even when attempting moderately to gaze steadily at the picture will cause a shifting of the image of this dividing line upon the retina, with the result that the pinkish after-image due to the green stimulus and likewise that due to the blue stimulus will in shifting above and below the horizon line produce a vivid effect. Such phenomena often greatly add to the "life" of a painting.

After steadily looking at a colored object for some time the color appears to become less saturated and often there is an apparent change in hue. If a small piece of black paper on a larger background of red be fixated, or looked at steadily for a few moments, and the black paper suddenly removed without disturbing the fixation in its place will be seen a red spot more luminous than the surroundings and of a more saturated reddish appearance.

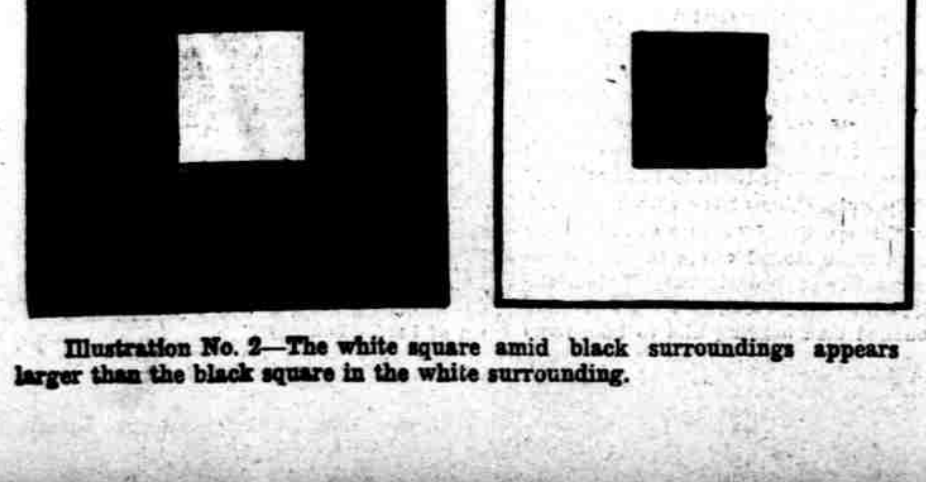


Illustration No. 2—The white square amid black surroundings appears larger than the black square in the white surrounding.

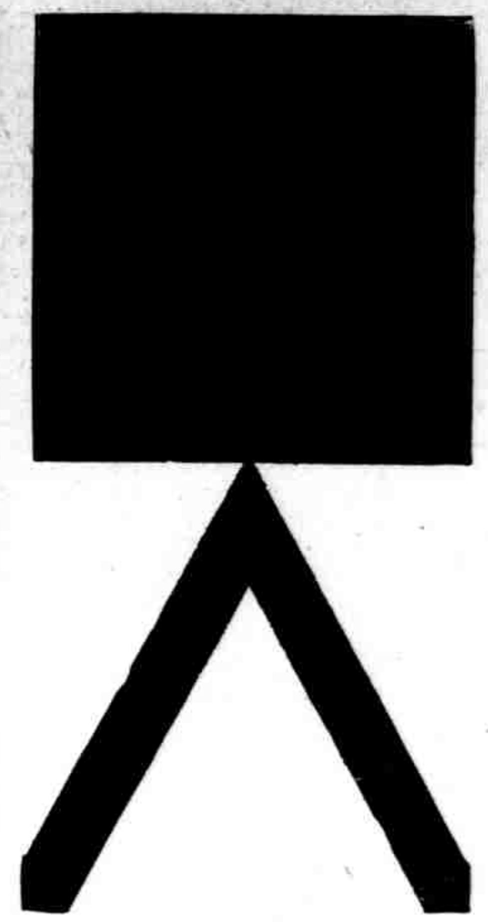


Illustration No. 1—Showing the effect of simultaneous contrast. The V's are of equal brightness.

Successive contrasts further complicate the appearance of colors. After stimulating the eye with red light, if the eye is suddenly fixed upon a green color the latter will appear more intense or saturated in color for a moment than if the eyes had not been previously stimulated by red light. On alternating these colors by means of a rotating disk at low speed very brilliant effects are seen.

Such successive contrasts are of importance in the study and application of color science. For instance in permitting the eye to rove over a painting or brilliantly colored rug the appearance of the various individual colors is influenced by the previous retinal stimulation.

Simultaneous contrast is another exceedingly interesting subject. Simultaneous contrast, for example, takes place when on viewing a gray pattern on a dark background it appears brighter than when viewed upon a light background. Illustration No. 1 was originally made by cutting the two figures in the form of a V from the same gray paper. On placing them as shown, one on a black and one on a white background, the one on a white ground appears darker than the other. The effect is so persistent that a much darker gray can be placed upon the black background and yet it will appear brighter than the one on the white ground. In fact it is practically impossible to make both appear alike by decreasing the brightness of the gray V on the dark ground.

If several gray papers of different shades be placed edge to edge in an order that goes from dark to light or from light to dark the edge of a lighter gray strip that is adjacent to a darker one will appear brighter than the other edge of the lighter gray strip. Such a specimen can be obtained by exposing a photographic plate in a very weak light by pulling out the slide of the plate holder a half inch at a time at regular intervals.

A striking demonstration of brightness contrast can be performed by viewing a gray paper through a hoe in a white unilluminated screen. It appears very bright in contrast to the dark surroundings. On illuminating the white surroundings it is possible to make the former bright spot appear very dark by contrast.

When two colors such as red and green are juxtaposed they are accentuated in saturation and appear deeper in hue. In the case of these two colors they appear to move further apart in hue. When the two colors are separated the contrast effect practically disappears. If a disk of green be placed upon a larger disk of red the contrast is very effective but if the smaller disk is outlined by a black circle the effect is reduced. If a gray figure is placed upon a green background the gray figure will appear of a pink hue. The contrast hue produced in this manner is approximately, though in general not exactly, complementary to the exciting color.

Colored shadows were noticed by such a great colorist as Leonardo da Vinci. These are illustrated by casting the shadow of a pencil on white paper by light entering the window. Only black and white contrast is seen. However, if from another direction light from an incandescent lamp is permitted to fall on the paper another shadow is produced. If the two shadows are approximately of the same brightness the contrast colors of the shadows are very striking.

The white ground on the outside of the shadows is receiving the mixed light from the two illuminants while the shadow cast by daylight receives light from only the incandescent lamp and appears yellow. The other shadow receiving only daylight appears blue. Shadows in a landscape appear blue because they receive light from the sky and they often appear more vivid owing to the contrast effects.

Irradiation is the name that is given to the phenomenon of the apparent increase in size of objects as they are increased in brightness. The crescent of the new moon appears larger than the remainder of the disc. A filament of an incandescent lamp appears to increase in diameter as its temperature is raised from a dull red to its normal operating temperature.

Some scientists say that this is due to the spreading of the image in the retina of the eye on account of a stimulation of nerves outside its actual geometric boundary. Others say that it is due to aberrations in the optical system of the eye.

In Illustration No. 2 the inner white square appears larger than the inner black square under high illumination, yet both are identical in size. The phenomenon of simultaneous brightness contrast is also evident, the white square amid black surroundings appearing brighter than the larger white square. Such effects are also perceptible with colored objects.